Senior Thesis

Subsurface Stratigraphy of Middle Cambrian-Middle Ordovician Rocks in Central Morrow County, Ohio

by
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INTRODUCTION

The purpose of this thesis is to report on a subsurface study of the Middle Cambrian to Middle Ordovician stratigraphic section in central Morrow County, Ohio. Stratigraphic units discussed are the Knox Dolomite, Wells Creek Shale, Black River Group, and the Trenton Limestone. Although the primary focus of this report is on the Knox Dolomite it is interesting to observe how its structure influenced the deposition of the overlying units. For this reason I included the other units as well. The Knox Dolomite, in particular, is a major petroleum target in Ohio. All the results are based on electric logs, which were obtained from the Ohio Geological Survey in Columbus, Ohio.

LOCATION

The study area is located in Mount Gilead, Franklin and Congress Townships, Morrow County, Ohio (Figures 1, 2). In Franklin Township, sections 3, 4, and 5 are in the study area. In Mount Gilead Township, sections 29 and 32 are in the study area. In Congress Township, sections 27, 28, 33, and 34 are in the study area. Location of specific wells used in this study are given in Figure 3. Also, one should note that not all of the wells located in the sections listed above were used in every part of this study.

STRATIGRAPHY

Units studied, in ascending order, are the Middle Cambrian-Ordovician Knox Dolomite

(Babcock, 1994; Coogan and Maki, 1988b), the Ordovician Wells Creek Formation (Coogan and Maki, 1988a), the Ordovician Black River Group, and the Ordovician Trenton Limestone (Figure 4). In central Morrow County, approximate thicknesses of the studied units are: Knox Dolomite, 95 m; Wells Creek Formation, 0 to 18 m; Black River Group, 150 to 180 m; and Trenton Limestone, 15 to 24 m. The Trenton Limestone is dominated by limestone; the Black River Group consists of shale, dolostone, and limestone; the Wells Creek Formation is dominated by shale; the Knox Dolomite is dominated by dolostone.

Surfaces that have been mapped, based on subsurface logs, are the top of the Knox Dolomite (Figure 7), the top of the Black River Group (Figure 6), the top of the Trenton Limestone (Figure 5). Additionally, the thickness of the Wells Creek Formation was contoured (Figure 8).

ECONOMIC VALUE

The principal economic value of the Knox Dolomite in Ohio lies in the hydrocarbons that are trapped in the formation. In different regions of the state, drillers or stratigraphers have adopted various names for the Knox Dolomite: Beekmantown, Trempealeau, and Copper Ridge; all are oil or gas producers. In Morrow County, the Knox is especially noteworthy for oil and gas production. One well, the Orrie Myers #1 well, drilled in 1961 in Canean Township section 33, had an initial production of 600 barrels of oil per day (bpd) (Janssens, 1973). With this discovery there was a massive drilling surge into Morrow and adjacent counties. By 1971, approximately 3,200 drilling permits had been issued for Morrow County (Janssens, 1973).

In Morrow County the main targets for hydrocarbon production are the highs on the Knox Dolomite (drillers' term, Trempealeau). These highs can be found by seismic methods and by well data (Figures 7, 8). These subsurface highs are capped in most locations by the Wells Creek Formation, which is composed of impermeable shale and siltstone (Janssens, 1973). Some wells also have produced oil or gas from the thin porous dolostone beds from the basal Black River

Group (Janssens, 1973).

METHODOLOGY

To map the top of the Knox Dolomite, I used elevations picked from gamma-ray and neutron density logs on file at The Ohio Division of Geological Survey, Columbus, Ohio (Figure 9). Although several seismic lines have been run through my study area, these data were only used to check my results from analysis of the electric logs. The tops of the Black River Group and the Trenton Limestone were picked from gamma-ray and neutron density logs. The thickness of the Wells Creek Formation was calculated by subtracting the elevation of the top of the formation to the elevation of the top of the Knox Dolomite.

COMPUTER AND DATA INPUT PROCESSES

Upon selection of the study area I compiled permit numbers of wells that reached the Trempealeau (McDonald, 1995). Permit numbers were obtained for wells in the study area, and for wells bordering the study area. The reason for this was to help eliminate as many edge effects as possible in my study area once the maps were computer drafted. Using electric log data, tops of the units of interest were picked and their elevations inputed into the computer. These data were entered into Stratafact, a computer program designed for geological mapping.

Next a printout of the total area where I had collected the data was made and redigitized. In this process there was only a 0.01 percent error in the redigitized locations. The UTM coordinate numbers for the given locations were then transformed into State Plane South Coordinates and exported into Radians, a computer program on the UNIX computer.

RESULTS

The top of the Trenton limestone in central Morrow County is located from approximately

1,600 to 1,900 ft (488 to 579 m) below sea level, and in my study area displays a 1.4 percent grade slope to the southeast. The structure contour lines of the Trenton become more irregular over drastic vertical changes in the Knox structure contour map (refer to figure 5). In the northeastern corner of Figure 5, there is a closed high present in section 23. This is due to a low quantity of data points for this particular area and also due to edge effects.

The top of the Black River Group in central Morrow County is located from approximately 1,700 to 2,000 ft (518 to 610 m) below sea level, and in my study area displays a 1.6 percent grade slope to the southeast. The structure contour lines of the Black River Group are almost identical to those of the Trenton Limestone. Edge effects in the Black River map are less pronounced than in the Trenton structure contour map.

The top of the Knox Dolomite in central Morrow County is located from approximately 2,240 to 2,540 ft (683 to 774 m) below sea level, and in my study area displays a overall average percent grade of 1.3 to the southeast. As shown in Figure 7, the structure of the Knox Dolomite in the study area is much more complex than the structures observed in either of the overlying units. Just within this small area one can observe many highs and lows on the Knox. Also, these highs appear to be separated from each other. Hydrocarbon reservoirs are likely to be associated with highs of these types. Some are proven reservoirs (Figure 3).

The structure of the isopach of the Wells Creek Shale follows the contours of the Knox Dolomite very well. This was expected and thus just verified by this report. The thickness of the Wells Creek Shale thickens in the lows of the Knox Dolomite and thins towards the hills of the Knox.

DISCUSSION

Upon reviewing the structure contour map of the Knox Dolomite (Figure 7) and the isopach of the Wells Creek Shale (Figure 8) a karst topography is displayed. Hydrocarbons are

trapped in the highs of the Knox and thus these highs are targets for hydrocarbons. There have been many seismic lines shot in Morrow County but I had access to three (which crossed my study area). All of these lines matched up very well with the highs and lows of my Knox structure contour map.

Thus, I think that the Knox Unconformity in Morrow County Ohio was subject to karsting back in the Ordovician. This Karsting has formed many highs and lows. Then the deposition of the Wells Creek shale covered most of the Knox Unconformity except for the very peaks of the larger highs. This shale being impermeable trapped the hydrocarbons thus creating a oil pool within the high. Thus the exploration of these pools was certain to occur.

CONCLUSIONS

In central Morrow County, Ohio the Middle Cambrian to Middle Ordovician stratigraphic section is represented by the Trenton Limestone through the Knox Dolomite. In Morrow County this is a subsurface interval and has an average thickness of approximately 750 ft (228 m) total. Looking at the units individually one observes that the approximate thickness of the Trenton Limestone is 70 ft (21 m), the Black River is approximately 510 ft (155 m), the Wells Creek Formation has a range from 0 to 60 ft (0 - 18 m), and the Knox Dolomite is approximately 312 ft (95 m) thick.

In the late Ordovician the Knox Dolomite was subjected to a Karst environment and thus was eroded heavily. This erosion created many isolated (from each other) hills, which today are potential hydrocarbon traps. Lying directly above the Knox Dolomite (except in the extremely high hills of the Knox) is the Wells Creek Formation. This creates a great seal against the Dolomite of the Knox. Thus, these highs are the targets that oil producers try to hit in this area. So, the largest factor in locating hydrocarbon reserves in Morrow county is ones understanding of the Knox Dolomite and its structure.

ACKNOWLEDGMENTS

I would like to thank the staff of the Ohio Division of Geological Survey, especially Dick Carlton, Allen Axon, Ron Riley, and James McDonald for allowing me access to resources and providing advice on geological interpretation using computers. Also, great appreciation goes to Loren E. Babcock of The Ohio State University for his guidance in helping me to prepare this thesis.

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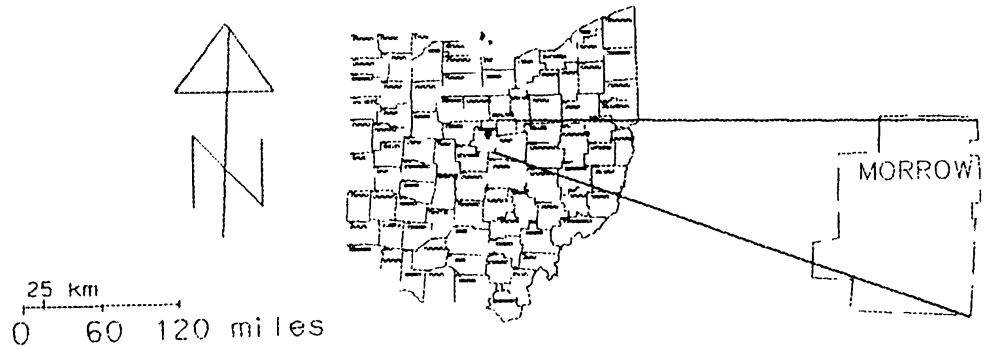

Figure 1. Location map. Study area is located in central Morrow County, Ohio (Figure 2)

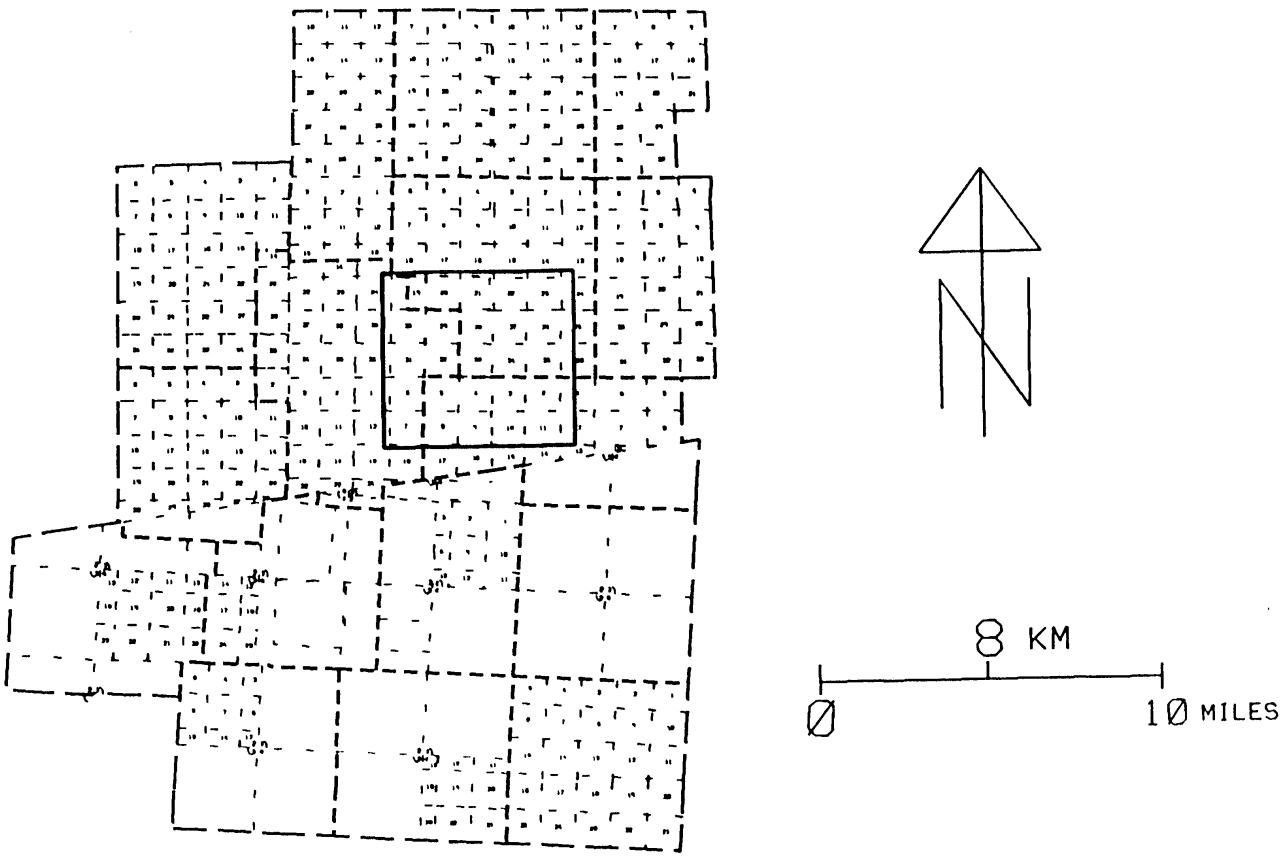

FIGURE 2. MAP OF MORROW COUNTY, OHIO, SHOWING TOWNSHIPS AND SECTION NUMBERS. STUDY AREA IN CENTRAL MORROW COUNTY IS OUTLINED BY A DARK LINE.

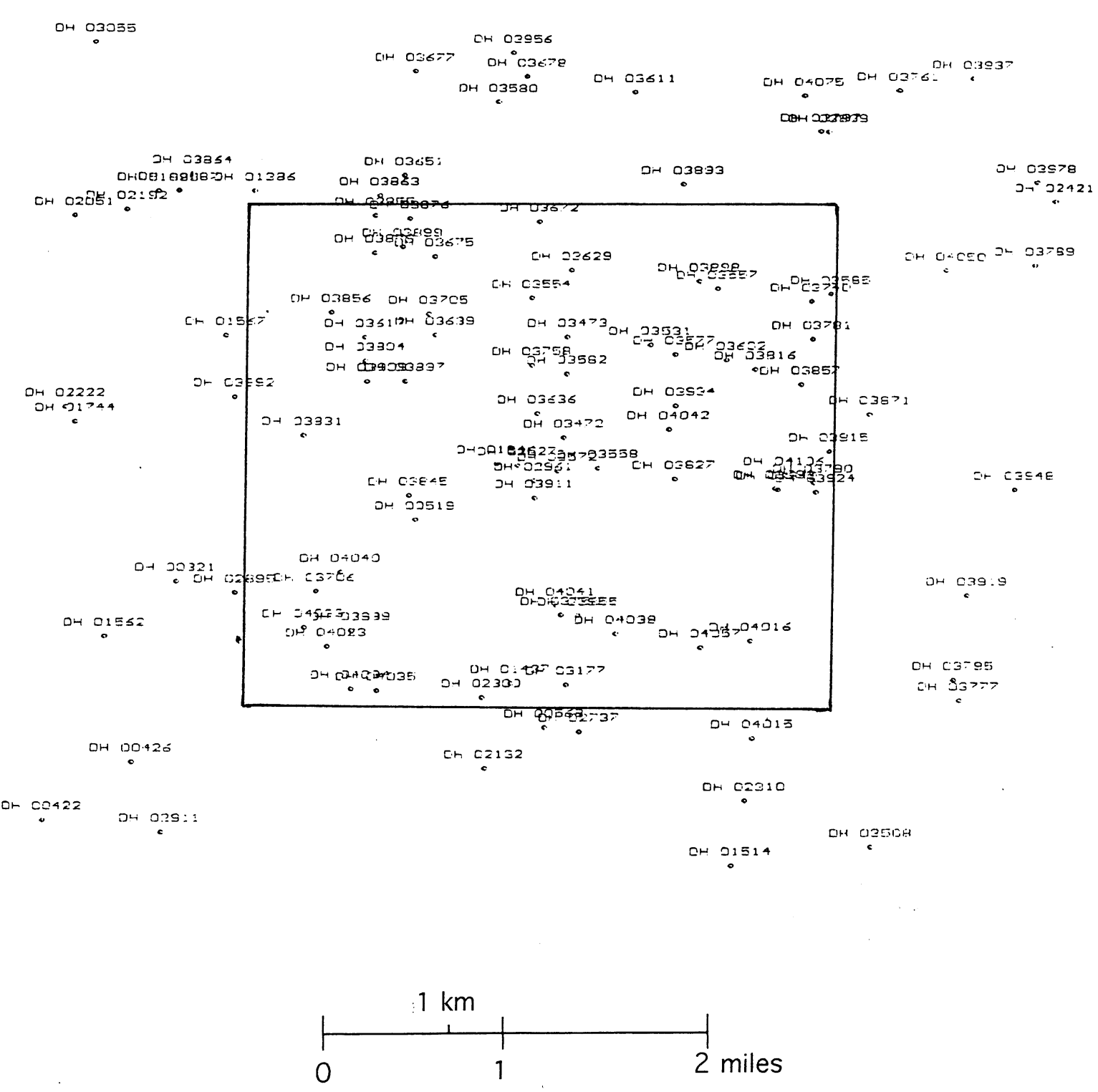

Figure 3. Locations of wells used in this study, as well as some wells in bordering areas. Wells are indicated by permit numbers.

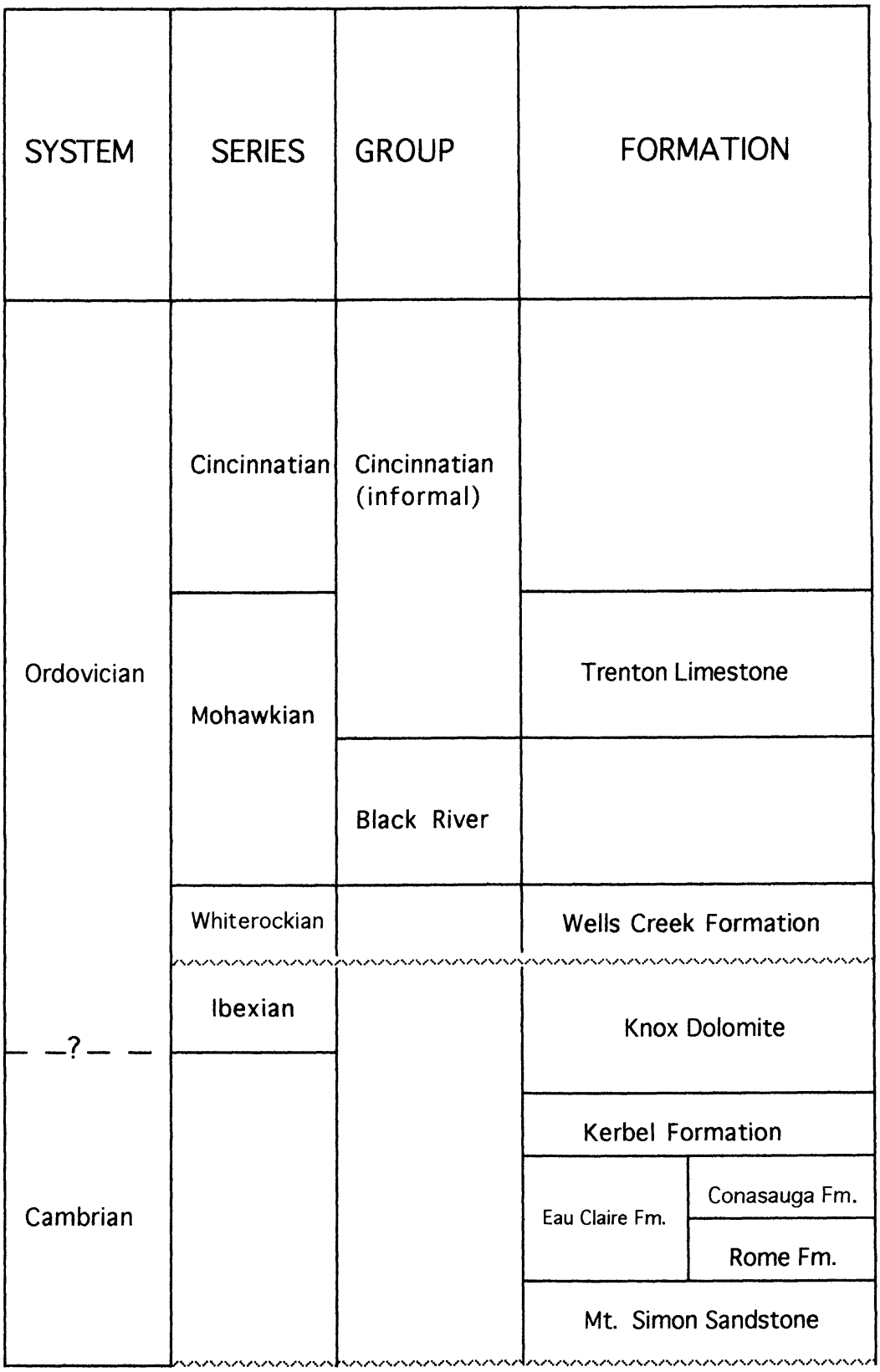

Figure 4. Generalized Cambrian-Ordovician section in northern Ohio (from Hull, 1991).

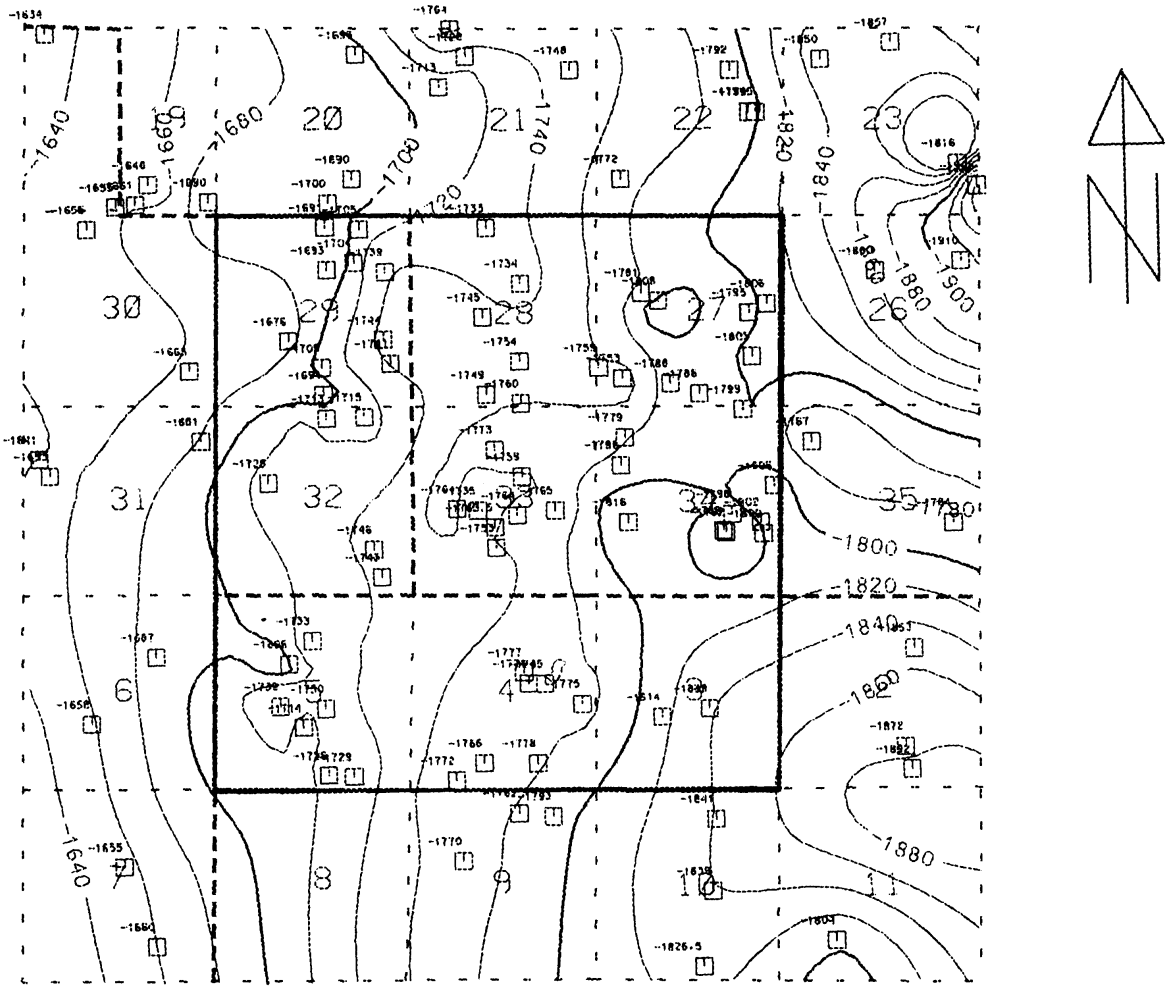

Figure 5: Structure contour map on the top of the Trenton Limestone.

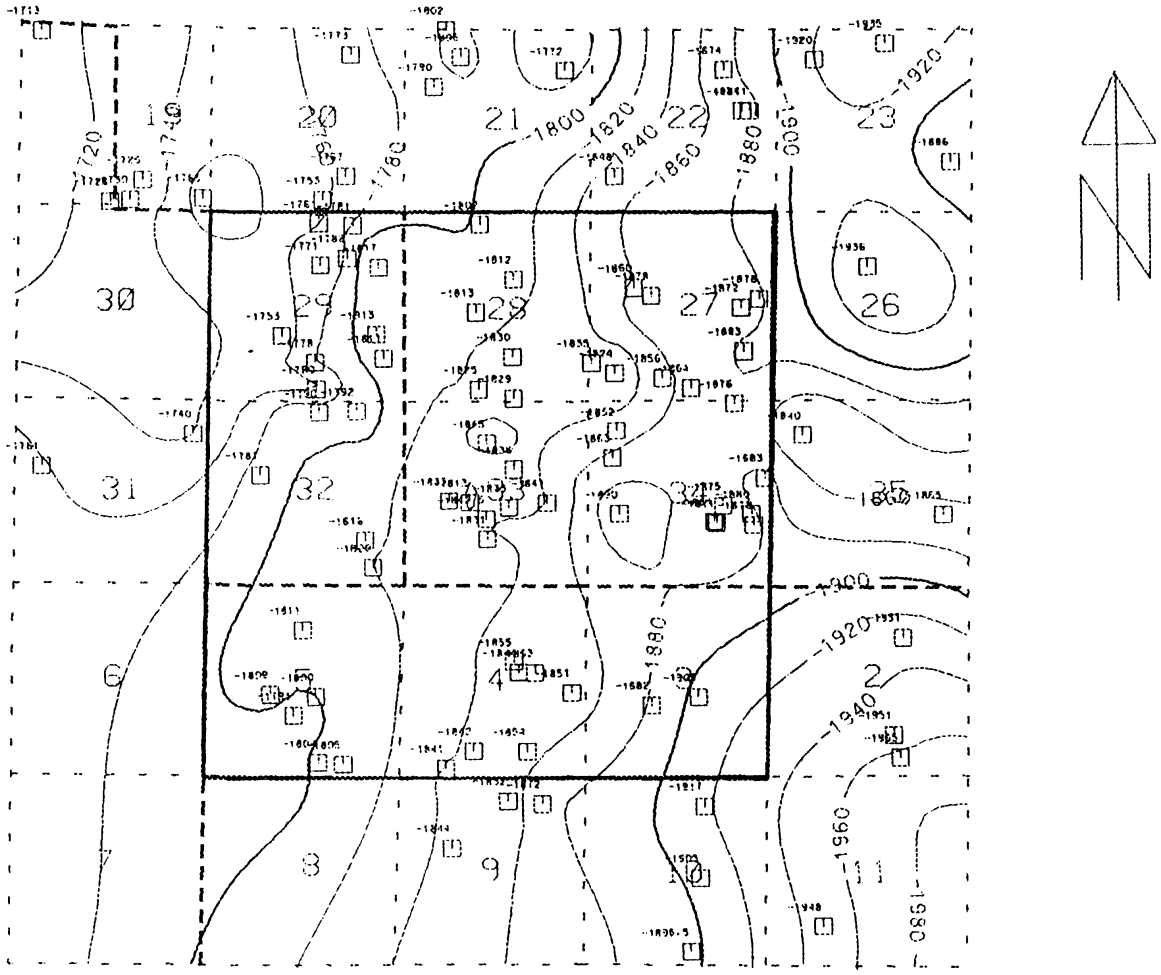

Figure 6. Structure contour map on the top of the Black River Group.

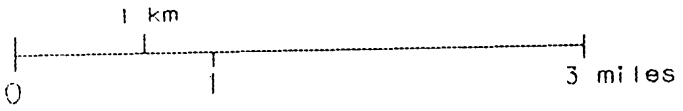

Figure 7: Structure contour of the Knox Unconformity

Figure 8: Isopach of the Wells Creek Shale

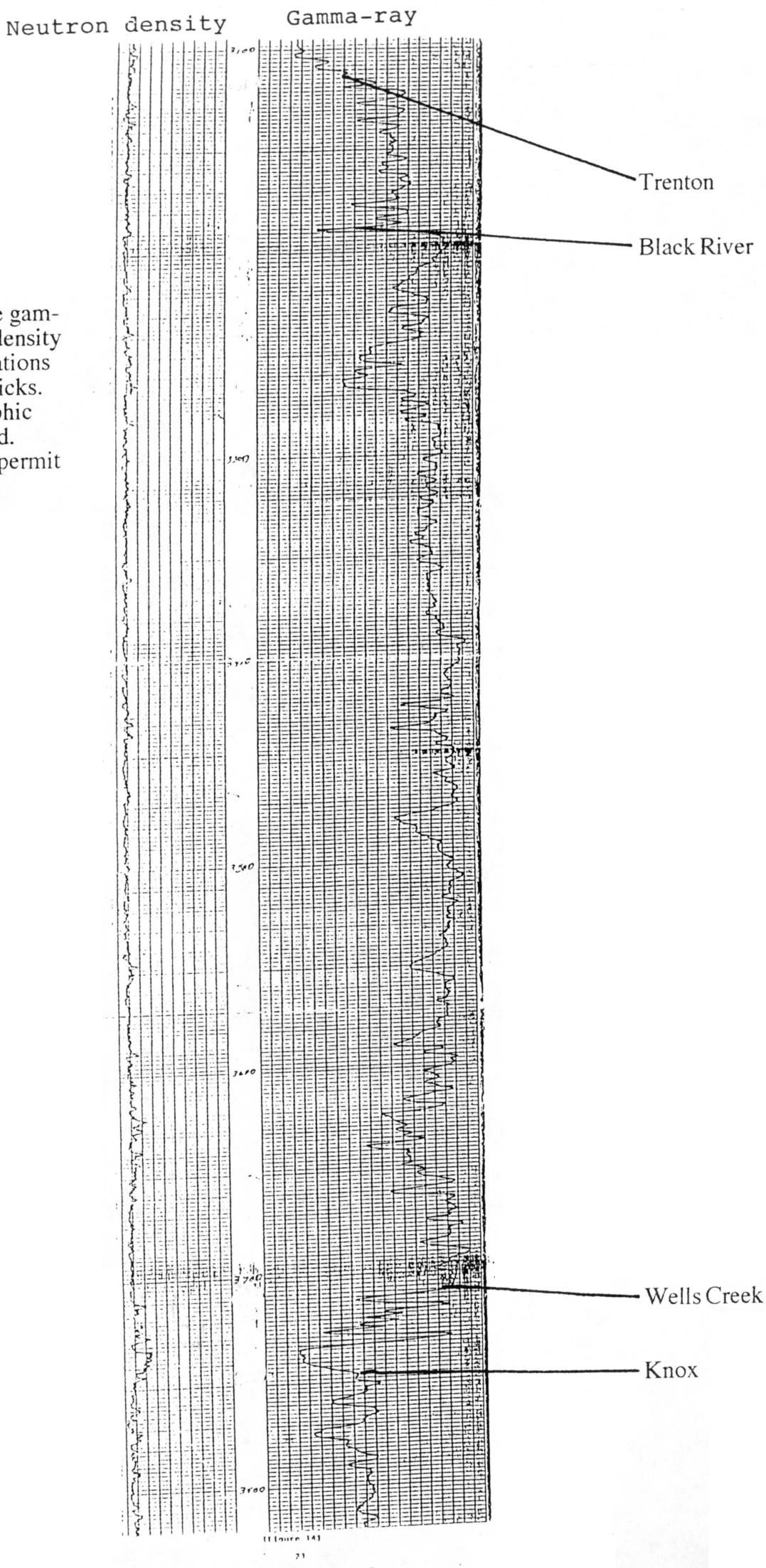

Figure 9. Sample gamma-ray, neutron density log showing locations of stratigraphic picks. Tops of stratigraphic units are indicated. Log is from well permit # 3827.